MORPHOLOGY OF ADULT AND LARVAL CESTODES FROM POULTRY*

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During the course of experimental studies on the life history of certain chicken cestodes described in the succeeding section of this work (Gutberlet, 1916) it was necessary to determine exactly the morphological features of the species, which to be sure, had been studied by others but were only partially and imperfectly known. In the former paper I recorded experiments which demonstrated the intermediate stage of *Choanotænia infundibuliformis* to be in the common housefly, *Musca domestica,* and discussed the symptoms of infection and methods of control for tapeworm diseases in chickens.

In this paper are taken up the structure of the adult and cysticercus of *Choanotænia infundibuliformis* (Goeze), and also the adult form of four other species occuring in chickens of this country.

As described more fully in the preceding paper the worms were removed from the intestine under water. The use of normal salt solution was avoided since it was found to be injurious. The cestodes were killed in a corrosive-acetic solution and preserved in 70% alcohol and glycerine. Best results were secured by staining in Delafield's or Ehrlich's acid hæmatoxylin and destaining in acid alcohol.

The five species discussed here were collected at two widely separated points, a farm at Hardy, Nebraska, and the poultry farm at the University of Illinois. These morphological studies were carried on at the Zoological Laboratory of the University of Illinois. This work was taken up at the suggestion of Dr. Henry B. Ward, to whom I am greatly indebted.

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Structure of Adult and Larva (Cysticercus)

A. ADULT

Choanotænia infundibuliformis (Goeze 1782) Railliet 1896

1. Diagnosis: Length 50 to 200 mm. Scolex (Fig. 2) small, rounded, or conoidal, about 0.4 mm. wide. Rostellum (Fig. 2, 3, *r*) 60 to 70μ in diameter, armed with a single row of 16 to 20 hooks (Fig. 8) 25 to 30μ long, with long dorsal root and short ventral root. Suckers prominent, elongated antero-posteriorly, length 180 to 210μ; breadth 135 to 175μ between the extreme outer edges. Neck short and unsegmented, somewhat narrower than broad. In specimens well extended neck much narrower than head. Anterior proglottids very short and as they become older funnel-shaped, much narrower at anterior than at posterior margins; posterior segments 1.5 to 2.5 mm. broad and 1.5 to 3 mm. long according to amount of contraction, with convex lateral borders, nearly as wide at anterior as at posterior margin. Genital pores irregularly alternating, situated one in each segment in the anterior third of the lateral margin, usually under cover of the backward projecting border of the preceding segment. Vas deferens (Fig. 14, *vd*) and vagina pass between excretory canals and dorsal to nerve trunk.

Male Reproductive Organs: Testicles (Fig. 14, *t*) 25 to 40 or more, 60 in some cases, in posterior half of proglottid, posterior and lateral to large yolk gland, within limits of excretory canals. Vas deferens passes forward and in anterior third of proglottid forms a mass of coils between ovary and excretory vessels from which it extends outward as a convoluted tube to base of cirrus pouch. Cirrus pouch (Fig. 14, 15, *cp*) ovoid in shape, 75 to 95μ in long diameter. Portion of vas deferens in cirrus pouch is much coiled. Cirrus 50 to 65μ long, armed with spines; outer surface of cirrus pouch forms base of deep genital cloaca.

Female Reproductive Organs: Vaginal opening in genital cloaca posterior to cirrus. Vagina posterior to cirrus pouch, after crossing ventral excretory canal dilated to form ovoid seminal receptacle, posterior and ventral to vas deferens, extending to well developed shell gland, 40 to 50μ in diameter located in front of middle of proglottid. Transversely elongated ovary (Fig. 14, *o*)

occupies anterior portion of middle field of proglottid in front of shell gland. Large yolk gland posterior to ovary and shell gland, irregular in shape, elongated transversely, with convex ventral surface and concave dorsal surface. Uterus (Fig. 16, *u*) developed as tube between anterior and ventral lobes of ovary. Gravid uterus fills up most of proglottid, extending beyond excretory canals on each side. Eggs oval (Fig. 7), with very thin membrane next embryo, followed by thick, smooth membrane 40 by 32μ to 45 by 36μ in diameter, and one or two outer membranes, very thin and wrinkled in preserved material. Diameter of outer membrane 65 by 40μ to 60 by 45μ; at each pole of outer membrane a delicate appendage. Embryonal hooks 18μ long. Embryo 32 by 22μ in diameter.

2. *Morphology:* The scolex of the living worm shows up very prominently and can be used as a distinguishing feature. When first removed from the intestinal wall the suckers appear distinct and the neck is much narrower than the scolex. Soon after the removal it often contracts and takes on the appearance of a flattened bulb which includes the neck and anterior segments (Fig. 1). This feature is characteristic of this species and is a factor which alone assists very materially in distinguishing it from others that occur in chickens.

The rostrum or crown of the scolex is somewhat pointed when the rostellum is enclosed within its sheath (Fig. 2). The rostellum is an ovoid structure with a bulbous expansion at its anterior end. It has a length of 140μ and a breadth of 60 to 65μ at its anterior end. A crown of 18 hooks is arranged in a single row around the bulbular anterior end. The structure of the wall is of a fibrous nature and presents a transversely striated appearance due to contraction. In the interior of the rostellum the structure is a connective tissue mass with few cells, some of which possess long processes. The hooks (Fig. 8) are 30μ in length with a long dorsal root and a short ventral root.

The rostellar sheath or sac (Fig. 3, *rs*) into which the rostellum is withdrawn is oval in shape and 230 to 240μ in length by 80 to 90μ in width at its broadest point. Histologically, the structure is that of a fibrous connective tissue type with spherical and spindle-shaped cells. The cells coming in contact with the rostellum, as

well as those on the outer edge of the sac, bear long processes. The outer layer of the rostellar sac is composed of longitudinal and oblique fibers of a muscular nature which probably have for their function the movement of the rostellum.

The four excretory canals, that have extended forward through the entire length of the body, unite in the scolex to form a ring (Fig. 3, *ex*), which lies in the tissue of the rostellar sac around the body of the rostellum.

The suckers are prominent. They are oval in shape and in preserved specimens measure 180 to 210μ in length and from 135 to 175μ in extreme breadth. In the center of each sucker there is a depression or an acetabulum, 30 to 40μ in diameter. The entire inner surface of the suckers possesses minute hooklets or spines (Fig. 4) 1.5 to 2μ long. These hooklets not only line the suckers but also extend over the entire surface of the scolex (Figs. 3, 5) and down onto the neck region; they disappear before reaching the first segment. They appear more distinctly on scolices that are somewhat contracted than on those that are well extended. These hooklets can be seen only in sections as they are too small to be distinguished readily in whole mounts.

Musculature: The longitudinal muscle fibers are arranged in bundles which are scattered, forming a loose irregular layer. The bundles are numerous and nearly of a uniform size. There are no transverse muscle fibers present except a few minute oblique fibers which connect some of the longitudinal fibers near the ends of the proglottids. Some dorso-ventral fibers are present, but they are not abundant.

Nervous System: The longitudinal nerve fibers are arranged in fiber tracts which approach the structure of a nerve cord. The individual fibers do not form a compact mass, but are more or less free in the tract. Nerve cells have no definite arrangement, but are situated irregularly along the fiber tract (Fig. 6). The nerve cells are somewhat spindle-shaped and quite large, being from 20 to 25μ long by 6 to 8μ wide with large nuclei. Transverse nerves are composed of individual cells with long processes extending transversely from the lateral fiber tracts. The transverse fibers are much scattered and have no definite arrangement except that they

are more numerous near the ends of the proglottids. Peripheral nerve cells are widely and irregularly distributed. They are more numerous at the anterior end of the proglottids, especially on the portion that is covered by the backward extension of the preceding segment.

Excretory System: The excretory system is fairly well developed in this form. The ventral canal (Fig. 14, *v ex*) is the larger, and has a diameter of 28 to 30μ. A transverse canal unites the two longitudinal canals in each segment. The dorsal canals (Fig. 14, *d ex*) are much smaller, having a diameter of 6 to 8μ and are not united by transverse connections. The four longitudinal canals extend anteriorly to the scolex where they unite to form a ring which lies in the rostellar sheath around the body of the rostellum. The vas deferens and vagina pass between the dorsal and ventral excretory canals.

Male Reproductive Organs: The testes vary in number, usually from 25 to 40, but in a few cases the number is much greater, being as high as 55 or 60. The testes are quite large, being from 40 to 55μ in diameter, and are located in the posterior half of the proglottid (Fig. 14, *t*), posterior and lateral to the yolk gland. The testes are not arranged in layers, but are grouped in a more or less compact mass almost entirely within the limits of the excretory canals. The vas deferens (Fig. 14, *vd*) in the anterior third of the proglottid forms a coiled mass at the side of the ovary, from whence it passes laterad to the cirrus pouch as a convoluted tube. The portion of the vas deferens inside the cirrus pouch is coiled, varying in extent in different specimens (Figs. 14, 15). The vas deferens passes into the cirrus. There is no seminal vesicle formed by the vas deferens in the cirrus pouch nor are there any accumulations of sperm cells. The cirrus pouch (Fig. 15) is ovoid in shape and is from 75 to 90μ in diameter. The wall is made up of layers of fibers which are both circular and oblique, forming a basket-like network which incloses the cirrus and a portion of the vas deferens. The outer wall of the cirrus pouch forms the inner wall of the deep genital cloaca. The cirrus is a compact structure from 50 to 65μ long and lined with spines. It is a slightly curved structure passing from the cirrus pouch and curving posteriorly

toward the vagina which is directly posterior to it. The cirrus was not observed extending from the genital cloaca, but was noted in some specimens curving toward the vagina, though not passing into it. A few sperm cells were present in the vas deferens, also in the vagina and the seminal receptacle.

Female Reproductive Organs: The large ovary (Fig. 14, *o*) lies in the anterior third of the proglottid and extends transversely across the segment. It has a length of 300μ and a breadth of about 75 or 80μ at its broadest point. It is irregular in shape, being composed of a number of lobes. The end which is nearest the genital pore is smaller than the other, allowing room for the mass of coils of the vas deferens, the vagina, and the seminal receptacle. The ovary is concave on the dorsal surface and convex on the ventral. On the dorsal surface of the end nearest the genital pore is located the seminal receptacle and the vagina. The ova are large and very distinctly shown in the ovary (Fig. 16). Posterior to the ovary is the large yolk gland (Fig. 14, 16, *y*) which lies about the middle of the proglottid. It is irregularly elongate in shape and extends transversely across the segment, having a length of from 120 to 130μ and a breadth of from 35 to 50μ. Immediately in front of and dorsal to the yolk gland and posterior to the ovary is the shell gland (Fig. 14, *sg*) which is slightly ovoid in shape, 40 to 50μ in diameter. A small duct, the vitelline duct (Fig. 16, *v*), passes from the yolk gland through the shell gland from which it receives a duct. The combined ducts after passing through the shell gland unite with the oviduct (Fig. 16, *ov*) which appears as a curved tube leading from the ovary. These united tubes or ducts pass anteriad and slightly ventrad into the uterus which develops as a blind tube in the region of the ventral lobes of the ovary. This blind tube (Fig. 16, *u*) grows in size and extends transversely across the segment. As it becomes larger the tube forms pockets which extend anteriorly and posteriorly and also dorsally, until it takes up the entire mass of the proglottid between the excretory canals. In gravid segments it even extends beyond the excretory canals. A small tube or duct, which is really the end of the vagina, connects the seminal receptacle with the yolk-shell gland duct and oviduct. This tube serves to carry the sperm to the eggs in the oviduct for fertilization. The

seminal receptacle (Fig. 16, *sr*) is a dilation of the vagina into an oval shaped structure which is about 50μ long and from 25 to 30μ in breadth at the widest part. From the seminal receptacle the vagina passes laterad, lying posterior to the cirrus pouch, and unites with the genital cloaca. The genital cloaca has its pore on the lateral margin near the anterior end of the proglottid. The pore is usually covered by the backward projection of the segment anterior to it. The vas deferens and vagina pass between the dorsal and ventral excretory canals and dorsal to the nerve tract. The vas deferens is dorsal and anterior to the vagina.

In the mature segments the uterus becomes filled with ova and it increases in size until it occupies the entire area between the excretory canals, even extending beyond the canals in the gravid proglottids. The uterus finally breaks up into compartments, each containing a single embryo. The embryos (Fig. 7) are about 32 by 22μ in diameter with onchospheric hooks 18μ long. Usually three membranes, but often four, enclose the embryo. The inner membrane is thin and closely surrounds the embryo; the next is heavy, being from 1.5 to 2μ thick, composed of fibrous layers with a few cells present. This layer is variable in thickness, depending considerably upon the amount of contraction of the segment, as it ranges in size from 40 to 32μ to 50 by 36μ, or it may be even slightly larger. Usually one (Fig. 7) and sometimes two thin membranes are found on the outside of the thick layer. These are often wrinkled and bear at each end an appendage formed from the outer membrane by which it is attached to the wall of the capsule or compartment of the uterus.

In this species the oldest proglottids drop off from the worm before they are fully mature. The embryos from the oldest segments on the worm do not show the characteristics of entirely mature ones, and there are distinct differences between them and those that have been separated from the worm for some time. Single proglottids that have separated from the worm are quite active and remain in the intestine for some time before passing out with the feces. Proof of this is furnished by the fact that a large number of the free proglottids are found in the intestine at any time. Even tho only a few worms are present in the intestine of a bird there is

usually a large number of free proglottids. If they did not remain in the intestine for a considerable length of time there would not be nearly as many. Further proof is furnished by the fact that the free proglottids have embryos which are mature, showing the onchospheric characteristics, while the oldest segments that are still attached to the worm have embryos that are not entirely mature. This same condition has been observed in *Davainea proglottina* as Blanchard (1891:435) states that the oldest proglottids separate from the others and remain in the intestine to become mature before passing out. The proglottids do not always separate from the worm singly, but may drop off in groups of three or four.

The fact that the proglottids separate from the worm before they are entirely mature is one of great importance in taking up experimental work for infection of intermediate hosts. If the embryos are fed to insects or other invertebrates before they are mature they will be digested, and thus infection cannot be produced.

B. CYSTICERCUS

The cysticercus of *Choanotænia infundibuliformis* was found in the abdominal region of the body cavity in the common house fly, *Musca domestica*. The flies had been fed on embryos from ripe proglottids of this species of worm, and at the end of twelve days were killed. The cysticerci appear to be nearly ripe or ready for transmission into the adult host. The time for the development of the cysticercoid varies with different species and under different conditions. Grassi and Rovelli (1892:85) found that *Davainea proglottina* developed from the onchosphere into a ripe cysticercus in less than twenty days. Schmidt (1894:9) found that the development of the cysticercoid of *Drepanidotænia anatina* (Krabbe) varied with the time of the year and the influence of the temperature. In the summer the embryo developed in an ostracod, *Cypris ovata,* into ripe cysticercoids in two weeks.

The cyst proper (Figs. 11, 12, *c*) containing the scolex is oval in shape, 220μ long and 120μ in diameter.

The bladder (Fig. 12, *b*) or tail, which is also oval in shape, is located against one side of the cyst and is somewhat flattened on that side. It is 220 to 230μ long and from 116 to 120μ in breadth.

The scolex is 80μ in breadth and 120μ in length; neck is 40μ in diameter and 30 to 35μ long; suckers are 55 to 60μ in diameter. The rostellum is 60μ long and 20μ in breadth, armed with a crown of 18 hooks arranged in a single row. These hooks (Fig. 9) are 30μ long with a long dorsal root and a short ventral root. The suckers are lined with numerous minute hooklets or spines 1.5 to 2μ long which extend over the edges of the suckers and also over the greater part of the surface of the scolex, including a part of the neck region. Schmidt (1894: 16) described cuticular hooklets on the suckers of *Drepanidotænia anatina*.

The size of the scolex may be somewhat variable as shown by those in the cysticercoids of *Drepanidotænia anatina* by Schmidt (1894: 10). In that species the intermediate host could be one of two or more species of crustaceans and the size of the cysticercoid varied with the size of the host in which it was parasitic.

The head of the rostellum is conical in shape, bearing a bluntly pointed apex anterior to the end of the dorsal roots of the hooks (Fig. 10, *r*). This part of the rostellum is composed of minute muscle fibers which are both circular and oblique. The rostellum is slightly broader below the circle of hooks as it is an oval shaped body.

The rostellar sac (Fig. 10, *rs*) is a deeply stained structure 10 to 12μ thick. It extends from 10μ below the hindermost part of the rostellum to the anterior extremity of the scolex, forming an oval shaped sac or sheath. It is composed of parenchymatous tissue with large heavily stained oval or spindle shaped cells which bear processes. The outer part of the sac is composed of a thin layer of fine fibers which help to give it a definite shape. At the lower edges of the sac the fibers are connected or associated to some extent with similar fibers that form the inner layer of the suckers. The anterior region of the rostellar sac, which forms the sheath for the free head portions of the rostellum, is constructed of an inner layer of fine fibers and an outer layer of large spindle-shaped cells, the most of which bear fibrous processes at one or both ends.

The suckers are composed of large spindle-shaped cells which are arranged perpendicular to the edge. These are heavily stained

and form a compact layer. The inner boundary of the suckers is composed of a layer of fibers which are both circular and oblique. Some of these at the upper edges are associated with similar fibers in connection with the rostellar sac.

The cyst is composed of two cell layers with an irregular cavity between them. The cells are large and irregular in shape with no special arrangement in the layer. Large intercellular spaces lie between the cells, thus forming a loose network structure, except at the base of the neck. At this point where the neck is attached to the inner layer of the cyst the cells are smaller and are in a compact mass. There is no definite boundary to the outer part of the inner layer as well as to the inner part of the outer layer of the cyst. Few cells with long connective processes extend across the cavity from one layer to the other. This then forms an irregular cavity (Fig. 11 *ca*) 2 to 20μ in width between the two layers of the cyst. This is the primitive cavity of Grassi and Rovelli (1889: 373). The two layers of the cyst are formed apparently by a fold which extends upward and inward from the base of the neck, forming the gastrula cavity of Grassi and Rovelli (1889: 402, *g*) and enclosing the scolex. This cavity varies in width from 3 to 10 or 15μ.

The bladder, an oval shaped structure, is located at one side of the cyst and is attached to it at the posterior end by a narrow connection (Fig. 12, *cn*). The posterior end of the cyst or the region caudad of the base of the neck is somewhat drawn out (Fig. 12). From this point is given off the attachment to the bladder or tail portion of the cysticercoid. The fact that this bladder is really a tail, even though it possesses a cavity, is shown by the presence of the onchospheric hooks, which are located at the end of the bladder opposite to that of the attachment of the cyst (Fig. 12, *oh*).

The order of arrangement of the onchospheric hooks is individual. In some specimens they are situated at the end of the bladder, while in others they are at the side. In some the arrangement is in a group, while in others they are in pairs. Some of my specimens show a pair of embryonic hooks in the layers of

the cyst between the base of the neck and the attachment of the bladder, while the other two pairs of hooks are located in the bladder.

The cavity of the bladder is formed apparently by a splitting or hollowing out of the cells of the tail, because the wall is continuous and of the same histological structure. The wall of the bladder is constructed of two layers, an inner cell layer and an outer cuticular layer. The outer cuticular layer is more or less striated on account of minute fibrils uniting it with the inner cell layer. Histologically, the structure of the inner layer is constructed of somewhat granular substance arranged in fibers forming a network which encloses clear spherical cells with large nuclei (Fig. 13). Outside of the cuticular layer is located the peritoneum of the host which lies upon the bladder and surrounds it as well as the cyst.

C. COMPARISON OF ADULT AND CYSTICERCUS

A comparative study of the adult and the cysticercoid shows the likeness which exists between them. The presence of the same number of hooks, having exactly the same size and shape as seen by comparing Figures 8 and 9. Minute hooklets of the same size are present in both cysticercoid and adult lining the suckers, the entire surface of the scolex and a part of the neck region. Rosseter (1891: 365) shows that the hooks on the rostellum and suckers of *Echinocotylus Rosseteri* undergo no changes during the act of transition from cysticercus to adult stage. The rostellar sac is of the same general shape in both. The head of the rostellum is not expanded in the cysticercoid as in the adult because it has not functioned as yet. This corresponds to figures as shown by Schmidt (1894, Pl. VI, Fig. A) of the cysticercoid and Krabbe (1869, Pl. VI, Fig. 114) of the adult of *Drepanidotænia anatina,* and by Grassi and Rovelli (1892, Pl. IV, Fig. 7, 8) of the cysticercoid and Blanchard (1891: 16) of the scolex of *Davainea proglottina.* No measurements are given for the rostellum of either the cysticercoid or the adult by the above authors.

There is a great deal of difference in the size of the scolex between the cysticercoid and the adult. In my specimens the

scolex of the adult is between four and five times as large as that of the cysticercoid. The scolex of the cysticercoid has as yet not functioned so that the musculature of the organs is not developed as in the adult, consequently is not nearly as massive. The cells also are smaller than those of the adult.

Schmidt (1894: 10, 44) shows that the adult scolex of *Drepanidotænia anatina* is about three times as large as that of the cysticercoid. He also states that the size of the cysticercoid may vary with the size of its host.

Different forms become modified in changing from the intermediate to the adult hosts as shown by Schmidt (1894) in *Drepanidotænia anatina,* Rosseter (1891) in *Echinocotylus Rosseteri,* and Grassi and Rovelli (1892) in *Davainea proglottina.*

Onchospheric hooks in the wall of the tail are the same size (18μ) and shape as those of the embryos found in the mature proglottids.

A consideration of these factors of morphological significance which demonstrate the resemblances between the cysticercoid and adult, indicates clearly that this cysticercoid is the intermediate stage of *Choanotænia infundibuliformis.*

OTHER CHICKEN CESTODES IN THE UNITED STATES

1. *Davainea tetragona* (Molin 1858) Blanchard 1891

Diagnosis: Length 10 to 250 mm. by 1 to 2.5 mm. in breadth, varying with state of contraction. Scolex (Fig. 19) 175 to 215μ in diameter, with retractile rostellum 25 to 50μ in diameter, armed with single row of about 100 hooks. Rostellar hooks (Fig. 20) 6 to 9μ long through longest axis, hammer-shaped, with long ventral root and short dorsal root, prong short and recurved. Suckers oval, 60 to 110μ in diameter, armed with 8 to 10 rows of small hooks of various sizes. Acetabular hooks (Fig. 21) range in size from 4 to 8μ through longest axis, having thorn-like prong, short dorsal root, and longer flattened ventral root, which is shorter than prong. Neck long and slender, but often as broad as head. Segments trapezoidal and imbricate, edges of strobila serrate. Oldest segments usually longer than broad, often bell-

shaped. Genital pores usually unilateral, situated one in each segment, at or in front of middle of lateral margin, frequently marked off by papilla. Male and female canals pass on dorsal side of nerve and excretory vessels.

Male Reproductive Organs: Testes 20 to 30 in median field surrounding female organs, most of them lying on aporose side of latter. Vas deferens situated in anterior third of segment, beginning near median line, and extending in much convoluted course laterally to base of cirrus pouch which it enters and, after a few coils in basal portion of latter, passes into cirrus. Cirrus pouch pyriform, 75 to 100μ in length. Basal portion surrounded by prominent layer of longitudinal muscle fibers, neck with thick layer of transverse fibers. Cirrus without apparent spines.

Female Reproductive Organs: Ovary in middle of segment. Yolk gland posterior to ovary, irregularly reniform, slightly longer in its transverse axis, about 100μ in diameter. Shell gland prominent, 50μ in diameter, immediately in front of yolk gland. Vagina begins at genital pore, posterior to opening of cirrus pouch, at first very slender but at distance of 15 to 25μ from genital pore swells out into thick-walled tube, functioning as seminal receptacle. This extends transversely across segment and joins oviduct on dorsal side of ovary near median line. Oviduct, after being joined in shell gland by vitelline duct, proceeds forward and ends on dorsal side of ovary. Definite and persistent uterus not developed. Eggs pass from distal end of oviduct, become imbedded in fibrous and granular or gelatinous mass which fills up most of segment. This mass divides into 50 to 100 portions to form egg capsules, each surrounded by membrane and containing 6 to 12 or more eggs. Egg is surrounded by three envelopes,—inner, close to onchosphere, often scarcely visible; middle layer or envelope much folded, giving appearance of network between inner and outer membranes; and smooth outer envelope. The onchosphere measures 10 to 15μ in diameter; the outer envelope measures from 25 to 50μ in diameter.

One point noted here that has not been mentioned before by other authors is that the genital pores are irregularly alternate.

They are usually unilateral. The existence of this irregularly alternate occurrence of the genital pores may be an anomaly, but it is rather frequent for such a condition.

2. *Davainea echinobothrida* (Megnin 1880) Blanchard 1891

Diagnosis: Length up to 250mm; width 1 to 4 mm. Head (Fig. 22) 0.25 to 0.45 mm. in diameter, with retractile rostellum 100 to 150μ in diameter, armed with crown of about 200 hooks arranged in two rows. Suckers round or oval, 90 to 200μ in diameter, armed with 8 to 10 rows of hooks. Rostellar hooks (Fig. 23) similar to those of *Davainea tetragona,* but larger, measuring 10 to 13μ in length. Acetabular hooks (Fig. 24) likewise similar to those of *D. tetragona,* but also larger; size variable, smallest being 7 or 8μ in length and largest measuring from 14 to 16μ. Neck thicker and generally shorter than *D. tetragona,* nearly equal to width of head. Strobila resembling that of *D. tetragona,* but serrate border more pronounced. Oldest segments in preserved specimens also differ from those of *D. tetragona,* being less elongate and frequently marked by median constriction. Owing to this constriction adjacent borders of most posterior segments pull apart in median line and remain joined only at sides, giving rise to median series of openings through posterior portion of strobila. Genital pores irregularly alternate, or sometimes almost entirely unilateral, situated one in each segment posterior to middle of lateral margin. Male and female canals pass on dorsal side of nerve and excretory vessels.

Male Reproductive Organs: Testes 20 to 30, arranged in median field surrounding female glands as in *D. tetragona.* Vas deferens lies in anterior third of segment much as in *D. tetragona.* Cirrus pouch flask-shaped, 130 to 180μ in length. Basal portion globular or ovoid, surrounded by layer, about 10μ thick, of longitudinal muscle fibers inside of which is a layer about 12μ thick of transverse fibers. Neck of pouch measures 50μ to 75μ in length by 15 to 20μ in diameter, surrounded by layer of transverse fibers thickened at distal end to form sphincter. According to Mégnin, the cirrus is armed with minute spines.

Female Reproductive Organs: Female organs same as in *Davainea tetragona,* and onchospheres (Fig. 25) are also similar

in structure and size, 14 to 15μ in diameter. Onchospheric hooks 6 to 7μ long. Egg capsules in groups of 6 to 12 or more, embedded in a fibrous gelatinous mass.

In the living specimens very little difference can be noticed except in size of the species *D. tetragona* and *D. echinobothrida*. They are both quite transparent and appear much alike in every respect in external appearance, except that *D. tetragona* is slightly more transparent, while the oldest segments of *D. echinobothrida* have very distinct median constrictions between them, appearing almost as a series of openings.

The chief differences between *D. tetragona* and *D. echinobothrida* are that in the latter the animal is larger, the hooks are more numerous and larger, and the structure and size of the cirrus pouches show a very distinct difference. There is also a difference in the pathological effect of these spiny-suckered forms. *D. echinobothrida* produces large nodules or ulcers in the intestinal wall. The scolex bores through the mucosa of the intestine and in some cases nearly through the muscular coats. This disease in fowls is termed "nodular tæniasis", as described by Moore (1895: 1), and is often mistaken for other diseases.

3. *Davainea cesticillus* (Molin 1858) Blanchard 1891

Diagnosis: Length 10 to 125 mm. Maximum width 1.5 to 3 mm. Head cylindrical (Fig. 28), sometimes spheriodal, 0.3 to 0.6 mm. wide and 0.2 to 0.4 mm. long. Suckers unarmed, about 100μ in diameter. Rostellum broad and flat or hemispherical, 0.25 to 0.35 mm. wide, armed with a crown of 200 to 300 hooks which are very unstable and easily lost, arranged in two ranks. Hooks (Fig. 29) 8 to 12μ long with short dorsal root and long ventral root. Neck very short. Anterior segments three to five times as broad as long; the following increase in size until they become equal in length and breadth and finally even longer than broad; borders overlapping. Genital pores irregularly alternate, one in each segment, somewhat in front of middle of lateral margin in young segments and nearer the middle in older segments. Vagina and cirrus pouch pass dorsal of the two excretory canals and nerve.

Male Reproductive Organs: Testes (Fig. 17, *t*) 20 to 30 in number in posterior portion of segment. Vas deferens much coiled before entering base of cirrus pouch, also coiled within latter. Cirrus pouch ellipsoidal, 120 to 150μ long by 55 to 70μ wide. Cirrus when protracted 10μ in diameter, armed with minute spines, and with bulbous enlargement 20μ in diameter at its base, where it becomes continuous with cirrus pouch.

Female Reproductive Organs: Vagina enlarged before reaching median line into small seminal receptacle (Fig. 17, *sr*). Ovary occupies middle field in front of testes. Yolk gland and shell gland posterior to ovary, ventral and dorsal, respectively, in relative position. Uterus at first in front of ovary as cord of cells; gradually increasing in size, finally occupies most of segment and frequently extends laterally beyond excretory canals. In oldest proglottids it becomes divided into compartments, or capsules, each containing a single egg. Embryo (Fig. 30) 36 by 27μ in diameter, with very thin membrane closely adherent to surface. Embryo further enveloped by thicker, smooth fibrous membrane, oval in shape, 45 to 40μ in diameter, with filament at each pole attaching to thin outer wrinkled membrane about 35 by 50μ in diameter: finally egg is surrounded by capsule composed of outer and inner membrane, latter closely adherent to or fused with outer egg membrane; and former more or less widely separated from latter and connected with it by number of septa.

One of the principal points noted here that is not mentioned by other authors is the size of the rostellar hooks. In my specimens they seem to be somewhat larger than those described by others. They have been described as being 8 to 10μ long, while my forms show many of them to be distinctly 12μ in length. A second point noted here is the method of the development of the uterus. The uterus develops in front of the ovary. It first appears as a solid cord of cells connected with the united ducts of the ovary, shell gland, and yolk gland. The solid cord of cells which later gives rise to the uterus becomes hollow and appears as a blind sac or tube. This then grows in size, forming pockets, and finally fills up the entire proglottid.

This form is one of the most common chicken tapeworms and is the most easily recognized. It can be identified by the head with its broad, flat rostellum which shows up very prominently; the width of the most anterior segments is usually equal to or greater than the width of the head, and the eggs are distributed in individual egg capsules in mature proglottids.

4. *Hymenolepis carioca* (Magalhaes 1898) Ransom 1902

Diagnosis: Length 30 to 80 mm. Breadth at neck 75 to 150μ, at posterior end 0.5 to 0.7 mm. Segments three to five times or more broader than long throughout strobila. Head (Fig. 26) flattened dorso-ventrally, 140 to 160μ long, 150 to 215μ wide and 100 to 140μ thick. Suckers shallow, 70 to 90μ in diameter, unarmed. Rostellum unarmed; in retracted position 25 to 40μ in diameter and 90 to 100μ in length, with small pocket opening to exterior in anterior position. Unsegmented neck portion of strobila 0.6 to 1.5 mm. long. Genital pores almost entirely unilateral, a single pore being located in each segment slightly in front of middle of right-hand margin.

Male Reproductive Organs: Testicles three in number, normally two on left and one on right of median line. On dorsal side of inner end of cirrus pouch vas deferens is swollen into prominent seminal vesicle (Fig. 18, *sv*) which may attain a size of 70 by 50μ. Cirrus pouch (Fig. 18, *cp*) in sexually mature segments 120 to 175μ long by 15 to 18μ in diameter; almost cylindrical, slightly curved toward ventral surface of segment; on outer surface about 20 longitudinal muscle bands, 2 to 3μ in thickness, very prominent in cross section; vas deferens enlarged within cirrus pouch to form small seminal reservoir occupying proximal two-thirds of pouch; distal third of portion of vas deferens within pouch very slender, about 1μ in diameter and functions as cirrus. Genital cloaca 12 to 36μ deep.

Female Reproductive Organs: Opening of vagina in floor of genital cloaca, ventral and posterior to cirrus opening. First portion of vagina very narrow, 1μ in diameter. Small vaginal sphincter 8 to 10μ from vaginal opening. On inner side of sphincter vagina gradually increases in diameter, and in sexually mature

segments swollen into prominent seminal receptacle (Fig. 18, *sr*) which extends forward to anterior border of segment and inward considerable distance beyond proximal end of cirrus pouch. Ovary faintly bilobed or trilobed in posterior half of proglottid. Yolk gland spherical or ovoid, 30 to 40μ in diameter, situated near median line of segment, posterior and dorsal of ovary. Uterus at first solid cord of cells extending transversely across segment along anterior border of ovary; becomes hollowed out and grows backward on dorsal side of ovary; in gravid segments occupies nearly entire segment and filled with eggs. Eggs (Fig. 27) in gravid uterus spherical or oval, with four thin membranes, the two middle membranes often approximate to form thick layer which shows somewhat of a cellular or coarse granular structure. Diameter of outer membrane 36 by 36μ to 75 by 70μ, of outer middle membrane 30 by 30μ to 65 by 60μ, of inner middle membrane 26 by 26μ to 40 by 35μ, of inner membrane 24 by 16μ to 29 by 21μ. This membrane often lies so close to onchosphere that it can scarcely be distinguished from edge of embryo. Onchosphere is 18 by 14 to 27 by 19μ in diameter; length of embryonal hooks 10 to 12μ.

This form is thread-like and usually occurs in great numbers. It is very delicate and fragile and can be recognized by that fact alone, as it is the most fragile of the chicken forms known.

SUMMARY

1. By morphological comparison of the cysticercoids produced experimentally in flies and adult of *Choanatœnia infundibuliformis* they are shown to be identical.

2. Morphological points noted are the presence of minute hooklets on the suckers and entire surface of scolex in *Choanatœnia infundibuliformis*. The manner of development of uterus in the same species is by means of a blind tube which grows in size, forming pockets, and later breaks up into small compartments. In *Davainea tetragona* the genital pores were found to occur irregularly alternate in the proglottids. The hooks on the rostellum of *Davainea cesticillus* were found to vary in length from 8 to 12μ. The uterus in development first appears as a solid cord of cells which becomes hollow and in growing forms pockets, filling the entire proglottid.

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EXPLANATION OF PLATES

Unless otherwise stated all drawing were made with the aid of a camera lucida.

Abbreviations

b—bladder
c—cyst
ca—primitive cavity
cn—connection of bladder with cyst
cp—cirrus pouch
dex—dorsal excretory canal
ex—excretory ring in scolex
o—ovary
oh—onchospheric hooks
ov—oviduct
r—rostellum
rs—rostellar sac
sg—shell gland
sr—seminal receptacle
sv—seminal vesicle
t—testes
u—uterus
v—vitelline duct
va—vagina
vd—vas deferens
vex—ventral excretory canal
y—yolk gland

Plate V

CHOANOTAENIA INFUNDIBULIFORMIS

Fig. 1. Scolex much contracted. x40
Fig. 2. Scolex normal extension. x145
Fig. 3. Longitudinal section of scolex, showing rostellum and rostellar sac. x425
Fig. 4. Section of portion of sucker, showing hooklets. x425
Fig. 5. Section of portion of wall of scolex, showing hooklets. x425
Fig. 6. Longitudinal nerve tract, showing nerve cells with processes. x650

Plate VI

Fig. 7. A, B, C, D. Embryos from mature proglottid. x425
Fig. 8. Hooks from rostellum of adult. x425

CYSTICERCUS OF CHOANOTAENIA INFUNDIBULIFORMIS

Fig. 9. Hooks from rostellum of cysticercus. x425
Fig. 10. Section through scolex, showing rostellum with hooks and rostellar sac. x425
Fig. 11. Section through scolex and cyst, showing suckers with hooklets, structure of cyst and primitive cavity between layers of cyst. x425
Fig. 12. Reconstruction of cysticercus with cyst and bladder or tail, showing scolex in cyst and onchospheric hooks in bladder. x145
Fig. 13. Section of wall of bladder, showing histological structure and peritoneum of host. x425

PLATE VII

Fig. 14. Choanotaenia infundibuliformis. Reconstruction of mature proglottid, showing reproductive organs, excretory vessels, and nerve. x145

Fig. 15. C. infundibuliformis. Reconstruction of cirrus pouch showing cirrus and vas deferens, also part of vagina in connection with cloaca. x310

Fig. 16. C. infundibuliformis. Reconstruction of female reproductive organs, showing part of ovary, yolk gland, shell gland, oviduct, vitelline duct, uterus, and connection of ducts with uterus and seminal receptacle. x310

Fig. 17. Davainea cesticillus. Reconstruction of mature proglottid, showing reproductive organs and excretory vessels. x145

Fig. 18. Hymenolepis carioca. Reconstruction of mature proglottids, showing reproductive organs from ventral view. x145

PLATE VIII

Fig. 19. Scolex of Davainea tetragona. x145

Fig. 20. Hooks from rostellum of D. tetragona. x425

Fig. 21. Hooks from suckers of D. tetragona. x425

Fig. 22. Scolex of Davainea echinobothrida. x145

Fig. 23. Hooks from rostellum of D. echinobothrida. x425

Fig. 24. Hooks from suckers of D. echinobothrida. x425

Fig. 25. Embryos of D. echinobothrida, showing capsule and fibrous gelatinous mass in which it is embedded. x425

Fig. 26. Scolex of Hymenolepis carioca, after Ransom.

Fig. 27. A, B, C, D. Embryos of Hymenolepis carioca, showing enveloping membranes. x425

Fig. 28. Scolex of Davainea cesticillus. Free-hand drawing of living specimen well extended, showing rostellum.

Fig. 29. Hooks from rostellum of D. cesticillus. x425

Fig. 30. A, B, C, D. Embryos of D. cesticillus, showing enveloping membranes. x425

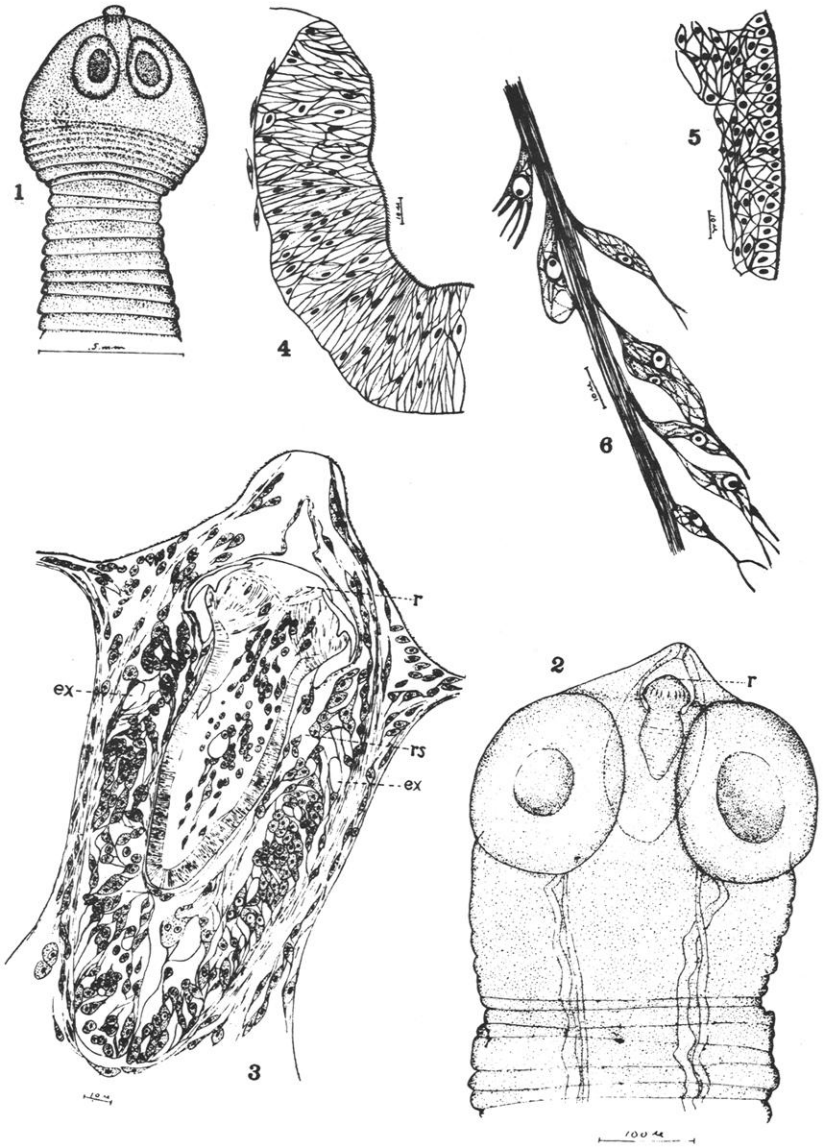
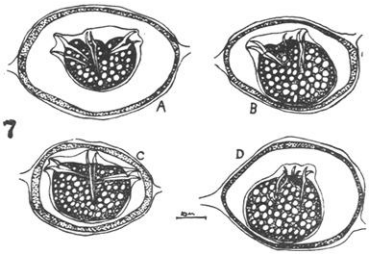
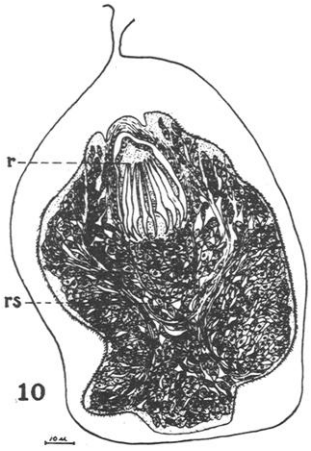
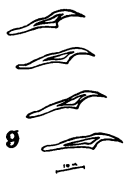
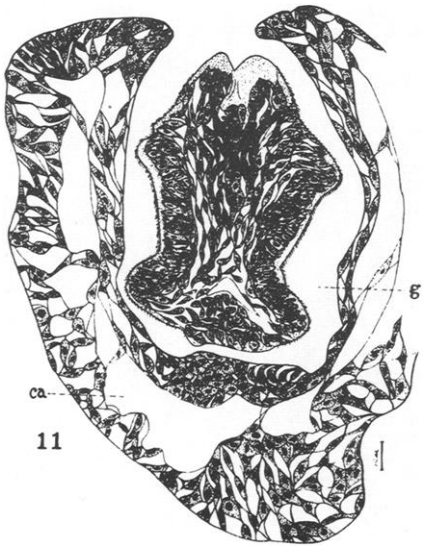


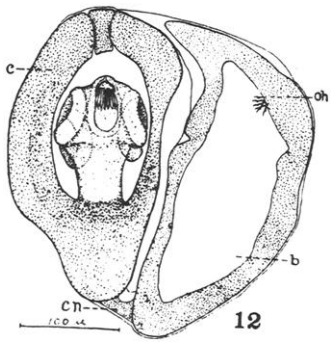
PLATE V

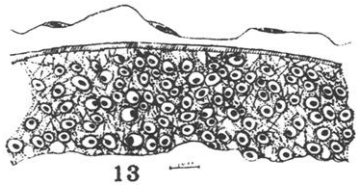












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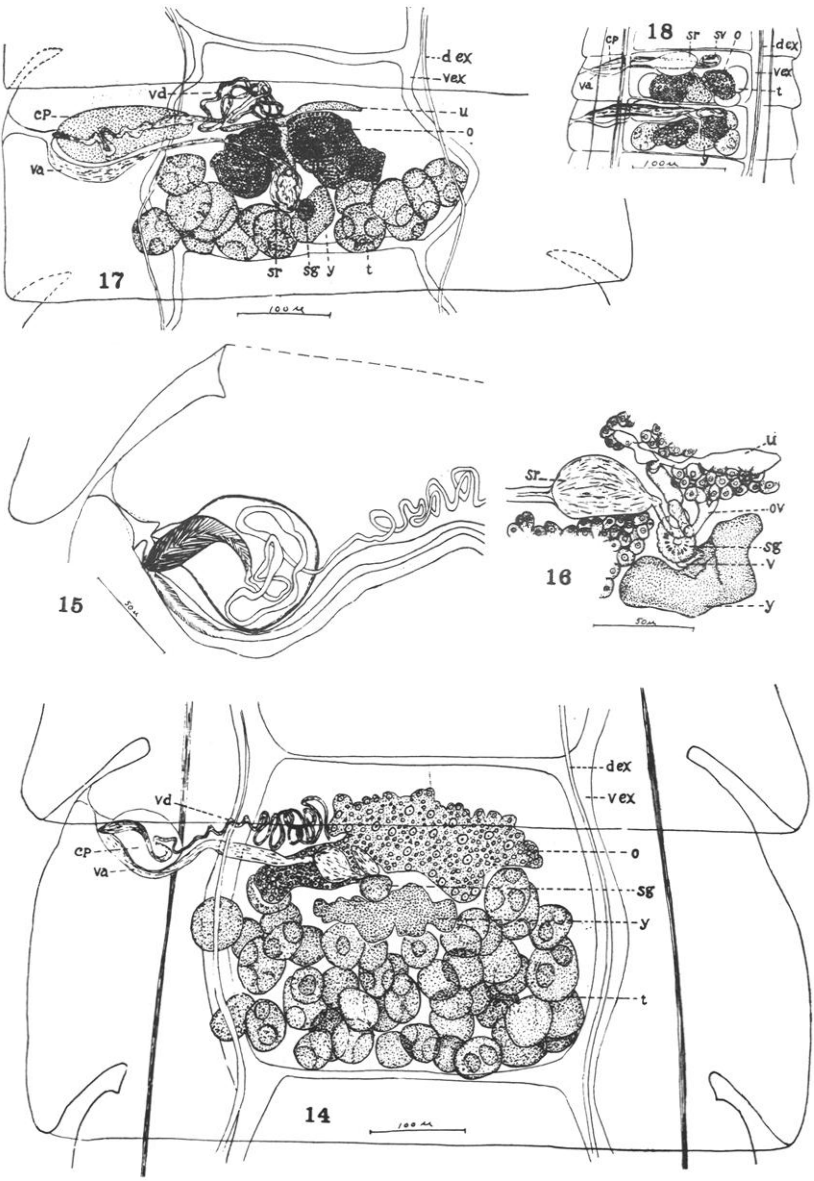
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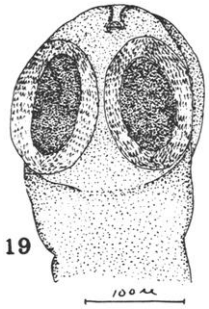
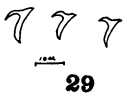
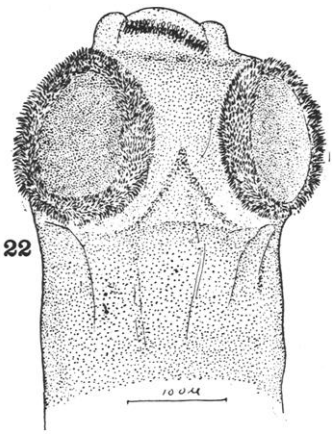
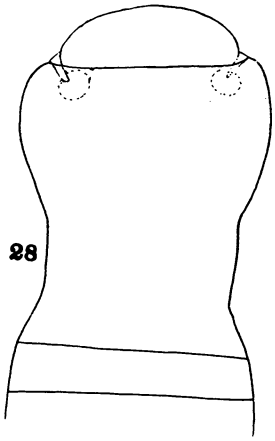
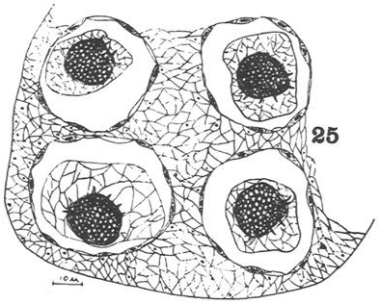
PLATE VII

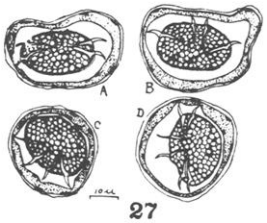












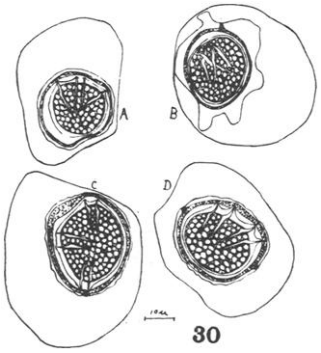


PLATE VIII